Inventor: MACKLIN ET AL
Serial No.: 10/069,011
Filing Date: 03/14/2002
Examiner: MERCADO J.A.
Group Art Unit: 1745

REMARKS

The Office action has been carefully considered, and reconsideration is respectfully requested.

Applicants thank the Examiner for his forbearance regarding the use of the British spelling of "aluminium" in the specification and thereby avoiding a plethora of amended paragraphs.

Claims 1-6 have been rejected under 35 U.S.C. 103(a) as being unpatentable of Miyabashi *et al*, (U.S. Pat. 4,945,014) in view of Ikeda *et al*. (U.S. Pat. 5,879,836.)

Applicants respectfully submit that the foregoing rejection is in error. Accordingly, reconsideration is requested in view of the following remarks and analysis:

The present invention discloses, and the claims relate to, an anode for a rechargeable lithium cell comprising carbon nanotubes where the nanotubes contain within them aluminum, tin or alloys containing aluminum, tin or silicon which can form alloys reversibly with lithium. Carbon nanotubes have a diameter of no more than a few nanometers (page 3, lines 12-14) but may be up to several micrometers long. The use of such an anode provides

improved capacity and reversibility for the cell because the nanotubes provide a stabilizing framework for the metal or alloy. Also, as the metal or alloy is contained within the nanotubes there is no change in volume when lithium intercalates and de-intercalates with the metal or alloy.

U.S. Patent 4,945,014 (Miyabashi) discloses a lithium cell where the anode comprises lithium and a carrier which is a carbonaceous material and a metal which can form an alloy with lithium. The carbonaceous material is described as being in the form of particles which are preferably 5 to 100μm in size. The particles are described as porous, but there is no indication of why the particles are porous or whether the pores perform a purpose.

Miyabashi describes in column 7 several methods of forming the carrier for the anode of the cell. These typically involve mixing metal powder with the carbonaceous particles and molding or heating the powders. There is no indication that the metal enters the pores of the carbonaceous particles. Indeed, in method 7 (column 7, line 67 and example 7) the metal is explicitly coated onto the surface of the carbonaceous particles and forms a layer 0.1 to 30μm thick. This method renders any pores in the carbonaceous particles irrelevant. Thus, there is no appreciation of the use of pores in

the carbonaceous particles for any particular purpose in Miyabashi.

U.S. Patent 5,879,836 (Ikeda) discloses a lithium battery where the anode is formed from a carbon fibril material. The patent describes the fibrils as being intercalated with lithium. There is no suggestion that the lithium enters the fibril tubes. Ikeda also mentions that the fibrils may be mixed with lithium intercalates (column 4, line 50), and this further suggests that lithium intercalates between the fibrils rather than inside them. Further, Ikeda discloses that the fibrils have "hemispherical septa spanning the hollow interior" at intervals along their length (column 2, line 34). Applicants submit that this means that the fibrils are blocked at regular intervals. Thus, if one attempted to fill the fibrils with another material such as a metal the fibril would probably be destroyed.

If one skilled in the art were to try to improve the cells of Miyabashi, they would be faced with a huge array of prior art. In the event that one skilled in the art were to choose to follow the teaching in Ikeda, then they could choose to use carbon fibrils in the cell disclosed by Miyabashi. However, this would not lead to the present invention, as the methods given in Miyabashi would not result in metals such as aluminum and tin being inserted into the carbon fibrils. As disclosed in the present invention, metals and

metalloids may be inserted into the carbon nanotubes by growing the tube in the presence of the metal or metalloid. In contrast, some of the methods for forming the anode disclosed in Miyabashi, such as pyrolysis of the carbon material with organometallics, would be likely to destroy a carbon fibril. Thus, even if one skilled in the art were to try to use a carbon fibril in a lithium ion cell of the type described in Miyabashi, this would not result in the present invention.

The present invention has the particular advantage that when lithium alloys with the metal or metalloid contained within (see claim 1, line 3) the carbon nanotube, there is no change in volume of the anode. This leads to a cell with improved reversibility and improved capacity, and therefore the present invention possesses an inventive step with respect to the disclosure of Miyabashi and Ikeda.

In view of the foregoing, applicants respectfully submit that claims 1-6 patentably distinguish over the teachings and suggestions of the prior art citations.

The Examiner has also referred to two other U.S. patents in his office action. U.S. Patent 6,090,363 (Green) discloses a method of opening capped carbon nanotubes and methods for

introducing metals and their oxides into the nanotubes. There is no disclosure in the patent of the use of carbon nanotubes in a lithium cell.

U.S. Patent 6,280,697 (Zhou) discloses the use of carbon nanotubes to intercalate lithium metal. However, there is no disclosure or suggestion that the tubes could be intercalated with a different metal or that this other metal inside the carbon nanotubes could be used to intercalate lithium.

In view of the foregoing, reconsideration is requested and allowance of claims 1-6 is courteously solicited.

Respectfully submitted,

April 11, 2005
Date

William H. Holt
Reg. No. 20766
Customer No. 25628

Law Offices of William H. Holt
12311 Harbor Drive
Woodbridge, Virginia 22192

Telephone: 703-491-8880
Facsimile: 703-491-8444

I hereby certify that this correspondence is being transmitted by facsimile this day to Julian Mercado at the United States Patent and Trademark Office, Art Unit 1745, to fax No. 703-872-9306.

April 11, 2005 Kathleen Holt
Date Signature